CALIFORNIA DEPARTMENT OF CONSERVATION
DIVISION OF MINES AND GEOLOGY

FAULT EVALUATION REPORT FER-232
SOUTHERN GREEN VALLEY FAULT
SOLANO COUNTY, CALIFORNIA

by
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Associate Geologist
February 24, 1992

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Division of Mines and Geology
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INTRODUCTION

Recently active traces of the Green Valley fault in the Benicia/Cordelia study area are evaluated in this Fault Evaluation Report (FER) (Figure 1). Traces of the Green Valley fault were zoned for special studies in 1974 in the Fairfield South and Port Chicago 7.5-minute quadrangles (CDMG, 1974, 1977) (Figure 1). The northern Concord fault in the Port Chicago* quadrangle was revised in 1977 (Hart, 1976), but the Green Valley fault was not evaluated at that time. The Green Valley fault in the Cordelia and Mt. George quadrangles was evaluated in 1982 by Bryant (1982). The SSZ Map of the Cordelia quadrangle was originally issued in 1974 and was revised in 1983. The SSZ Map of the Mt. George quadrangle was first issued in 1983.

Faults in the Benicia/Cordelia study area are evaluated as part of a statewide effort to evaluate faults for recency of activity. Those faults determined to be sufficiently active (Holocene) and well-defined are zoned by the State Geologist as directed by the Alquist-Priolo Special Studies Zones Act of 1972 (Hart, 1990). Traces of the Green Valley fault in the Mt. George quadrangle are not re-evaluated because of a lack of new data.

SUMMARY OF AVAILABLE LITERATURE

The Green Valley fault, located in the eastern Coast Ranges geomorphic province, is part of the San Andreas fault system. Topography in the study area ranges from relatively flat alluvial floodplains to moderately rugged relief in the western part of the study area. Developmental pressure is moderate to locally high in the Cordelia - Fairfield area.

Rocks offset by the Green Valley fault include Mesozoic and Tertiary sedimentary rocks and late Tertiary volcanic rocks (Sims and others, 1973). Pliocene Sonoma Volcanics, generally located east of the fault in the study area (Sims and others, 1973), are right-laterally offset an unknown amount along the Green Valley fault.

Late Quaternary deposits found along the Green Valley fault include fluvial, alluvial fan, and colluvial deposits of late Pleistocene and Holocene age and, locally, late Pleistocene and Holocene estuarine deposits (Sims and others, 1973). Late Pleistocene to historic landslides are abundant along the east-facing slopes underlain by late Mesozoic - early Tertiary sedimentary rocks west of the Green Valley fault (Frizzell and others, 1974; Manson, 1988).

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* The Port Chicago quadrangle was renamed in 1980 and is now known as the Vine Hill quadrangle.

The Green Valley fault zone is a N15°-20°W trending, generally vertically dipping right-lateral strike-slip fault (Figures 2a, 2b, and 3). A minor component of down-to-the east vertical displacement is suggested by both stratigraphic and topographic relationships (Weaver, 1949; Dooley, 1973b). The Green Valley fault can be mapped for at least 30 km from Suisun Bay north to Wooden Valley (Frizzell and Brown, 1976) (Figure 1). Cumulative right-lateral strike-slip offset is unknown, but probably is at least several kilometers, based on the geomorphic expression and length of the Green Valley fault.

The Green Valley fault was first recognized as a recently active strike-slip fault by Brown (1970), based on reconnaissance aerial photographic interpretation. Additional mapping that documented evidence of recent faulting includes Dooley (1972, 1973a, 1973b), Sims and others (1973), Frizzell and Brown (1976), Helley and Herd (1977), Pampeyan (1979), and Bryant (1982).

Aerial photographic interpretation by this writer of faults in the Benicia/Cordelia study area was accomplished using aerial photographs from Cartwright Aerial Survey (SOL, 1965), U.S. Department of Agriculture (ABO, 1952), and U.S. Geological Survey (1973, 1974). One day was spent in the field in July 1991 verifying traces of the Green Valley fault in the Cordelia quadrangle. One-half day was spent in the field in January 1992, principally to check for evidence of fault creep along the southern Green Valley fault. Results of aerial photographic interpretation and field observations by this writer are summarized in Figures 2b and 3.

FAIRFIELD SOUTH AND VINE HILL QUADRANGLES

LITERATURE REVIEW

Traces of the Green Valley fault depicted on the 1974 SSZ Map of the Fairfield South and 1977 SSZ Map of the Vine Hill quadrangles were compiled based on mapping by Sims and others (1973) at a scale of 1:62,500 and Dooley (1972, 1973a) at a scale of 1:24,000 (Figure 2a). Mapping by Sims and others (1973) was the principal source for both the Fairfield South and Vine Hill quadrangles (shown in pink on Figures 2a and 2b). This mapping locally was augmented by Dooley (1972, 1973a). A master's thesis by Dooley (1973b) is essentially the same as the mapping shown on the Fairfield South and Vine Hill quadrangles (uncolored in Figures 2a and 2b). Mapping of the Green Valley fault completed since the 1974 and 1977 SSZ maps were issued includes Frizzell and Brown (1976) (Figure 2a) and Helley and Herd (1977). Traces of the Green Valley fault of Helley and Herd (1977) were compiled from mapping by Frizzell and Brown (1976) at a scale of 1:125,000 and will not be evaluated in this FER.

Pliocene Sonoma Volcanics are offset along the Green Valley fault in the Fairfield South and Vine Hill quadrangles. Numerous landslide complexes are crossed by the fault. Dooley mapped the Green Valley fault as concealed through much of the large landslide complex in the southwesternmost corner of the Fairfield South quadrangle (locality 1, Figure 2a). Farther southeast Dooley mapped the fault as offsetting landslide deposits of latest Pleistocene to Holocene age (localities 2 and 3, Figure 2a). Holocene alluvial/esturine deposits are mapped as concealing the Green Valley fault south of Highway 680. Sims and others did not differentiate which deposits are offset and which deposits are concealed because they used only one symbol for the recently active traces of the Green Valley fault.

Mapping by Frizzell and Brown was completed in order to identify recently active traces of the Green Valley fault, based on air photo interpretation and field mapping. Traces mapped by Frizzell and

Brown (shown in orange in Figure 2a) generally correspond with previously zoned traces mapped by Dooley and Sims and others, although differences in detail exist (e.g. localities 4,5, and 6, Figure 2a). The Green Valley fault is delineated by geomorphic evidence of latest Pleistocene to Holocene faulting, such as right-laterally deflected drainages, closed depressions, linear tonal contrasts, and troughs (Figure 2a). Although Frizzell and Brown did not show the geology along the fault, several large landslide deposits that cross the fault are depicted. The fault generally offsets these landslide deposits.

Although not classified with respect to age, landslides along the Green Valley fault probably range in age from latest Pleistocene to late Holocene. The larger landslide complexes are probably latest Pleistocene because landslide morphology within these complexes generally is subdued and the extent of the mass is suggestive of a much wetter climate. Bates (1977) mapped the Dibble-Los Osos series soil on these large landslide deposits. This soil is characterized by Bt horizons to 45 centimeters thick with moderate to moderately thick clay films, suggesting a pre-Holocene age for the surface of these large landslide masses.

Both Sims and others and Frizzell and Brown mapped what is probably the principal active trace of the Green Valley fault west of Dooley's trace (locality 5, Figure 2a). Sims and others mapped a single trace that was projected (concealed) into Suisun Bay. Frizzell and Brown mapped two traces in the vicinity of locality 6 (Figure 2a). Their western trace is only about 0.6 kilometers long and was based on the observation that "drainages end". The eastern trace is located up to 60 meters east of the fault mapped by Sims and others. This trace was mapped using the short dash symbol, indicating that the trace is not as obvious, or well-defined. Frizzell and Brown mapped a short fault in the vicinity of locality 3 (Figure 2a) that locally coincides with a fault mapped by Dooley.

A site investigation by Lion and Ries (1988a) (AP-2184) reported evidence for recent faulting along the southernmost extent of the Green Valley fault (locality 7, Figure 2a). Eight trenches totalling about 275 meters were excavated in what is probably a late Pleistocene terrace deposit. A near-vertical, 21-meter wide zone of shearing was reported in trench T-1. A shear 7 meters from the northern end of the trench forms the southern boundary of a 2.7-meter wide fault zone characterized as a "very mixed blocky structure." The southern side of this zone consists of light gray-brown fine to medium grained clayey sand juxtaposed against brown sandy clay. The northern boundary is characterized by a 0.6-meter wide zone of abundant desiccation cracks extending to within 30 centimeters of the ground surface and involves what is probably a Bt horizon. Lion and Ries reported that no measurable strike-slip offset was observed along any of the shears. The only measurable displacement was an approximately 1 cm apparent vertical separation (down to the south) of thin bedding located 14 meters from the northern end of the trench. The consultant stated that there were no geomorphic features indicative of recent faulting at the site and that the unusual shape of the site precluded placing additional trenches on trend with the features observed in T-1. Lion and Ries were unable to obtain a strike for the fault zone in T-1. Thus, the trend of the fault shown in Figure 2a is only an assumption by the consultant.

AERIAL PHOTOGRAPHIC INTERPRETATION AND FIELD INSPECTION

The Green Valley fault is generally well-defined in the Fairfield South and Vine Hill quadrangles and is delineated by geomorphic features indicative of Holocene strike-slip offset (Figure 2b). I mapped two sub-parallel traces of the Green Valley fault in the Fairfield South and Vine Hill quadrangles, informally referred to in this report as the Western trace and Eastern trace (Figure 2b).

Western Trace

The western trace is probably the principal active trace and is delineated by geomorphic features indicative of Holocene strike-slip faulting. These features include right-laterally deflected drainages, sidehill benches, closed depressions, troughs and swales, beheaded drainages, and linear tonal contrasts including springs, seeps and vegetation lineaments (Figure 2b). Most of the fault crosses landslides of various ages and areal extent. However, relatively continuous fault features can be identified through most of these landslide deposits, such as linear sidehill benches and associated right-laterally deflected drainages (Figure 2b).

Mapping by Frizzell and Brown generally corresponds with the Western trace, although differences in detail exist (Figures 2a and 2b). Frizzell and Brown mapped a minor branch fault that splays off to the east, based on a saddle and a linear tonal contrast (locality 4, Figure 2a). The location of this minor branch fault was not verified by this writer, based on air photo interpretation.

The southern extent of the Western trace as mapped by Frizzell and Brown (south of locality 5) is located up to 60 meters east of the trace I mapped (Figures 2a, 2b). My location is believed to be the most accurate north of Highway 680, based on the general benched area and associated right-laterally deflected drainages (Figure 2b). I did not verify the soil color change cited by Frizzell and Brown south of Highway 680 (locality 8, Figure 2a). The Western trace south of the highway is delineated by moderately to poorly defined tonal lineaments in late Pleistocene terrace/landslide deposits and Holocene esturine deposits (Figure 2b). One of these vague tonal lineaments is located within about 30 meters of the fault reported by Lions and Ries (1988a, AP-2184) (locality 7, Figure 2b). A straight-line projection from the last well-defined trace would nearly coincide with the fault reported in trench T-1 by Lion and Ries.

The location of the Western trace corresponds fairly well with the trace mapped by Sims and others (1973) in the Vine Hill quadrangle (Figures 2a and 2b). The fault mapped by Sims and others may be located too far to the east south of Highway 680, however.

I mapped a branch fault just east of the Western trace near the VABM Goodyear benchmark that locally corresponds to the trace mapped by Dooley (1973b) (locality 5, Figures 2a and 2b). The fault is moderately defined by right-laterally deflected drainages, tonal lineaments, a linear break in slope, saddle, and a right-laterally deflected ridge (Figure 2b). However, I could not verify the southernmost location of the trace as mapped by Dooley and, locally, Frizzell and Brown (locality 9, Figures 2a and 2b). Both Frizzell and Brown and Dooley mapped this branch fault as turning to the east along the southwest side of a linear ridge underlain by Sonoma Volcanics. I mapped a linear break in slope and associated right-laterally deflected drainages south of this linear ridge, based on interpretation of 1952 USDA air photos (Figure 2b). These features indicate that faulting probably continues to the south and does not change to a more easterly trend as mapped by Dooley and Frizzell and Brown. However, landslide deposits may locally obscure or mimic features interpreted by this writer to be the result of active faulting. Vague tonal lineaments south of Highway 680 also infer the fault's location.

Eastern Trace

I mapped an Eastern trace of the Green Valley fault that locally corresponds with traces mapped by Sims and others and Frizzell and Brown, although considerable differences in detail exist (Figures 2a and 2b). The Eastern trace locally is well-defined and delineated by geomorphic features indicating Holocene offset (Figure 2b). The fault principally is delineated by a linear sidehill bench in Sonoma Volcanics and a linear vegetation contrast in a Holocene terrace surface (localities 10 and 11, Figure 2b). Southeast of locality 12 (Figure 2b) the fault is less well-defined and lacks the ephemeral geomorphic features indicative of Holocene offset. Features that delineate the fault here include linear drainages in bedrock, benches, saddles, a dissected shutter ridge, and occasional tonal lineaments (Figure 2b).

A large-scale linear ridge in Sonoma Volcanics indicates the location of a branch of the Green Valley fault north of locality 11 (Figure 2b), but this linear ridge lacks the small-scale ephemeral geomorphic features indicative of Holocene activity. Frizzell and Brown considered this strand to be active on the Cordelia quadrangle to the northwest (Figure 2a). Sims and others also mapped this trace. However, I did not verify the presence of geomorphic evidence of active faulting here. This trace was evaluated in Bryant (1982) and was not recommended for zoning.

CORDELIA QUADRANGLE

LITERATURE REVIEW

Five investigations for the hazard of surface fault rupture have been conducted across traces of the Green Valley fault since the revised map of the Cordelia quadrangle was issued in July 1983 (Rowley and McRae, 1985 [DMG file no. A-P 2072]; Lion and Ries, 1988 [DMG file no. A-P 2185]; and Cole and Pratt, 1991 [DMG file no. A-P 2521]; Carey and Wigginton, 1990; Carey and Wigginton, 1991). Four of the five site specific fault investigations identified Holocene active traces of the Green Valley fault in the immediate vicinity of and south of Highway 80 (Rowley and McRae, 1985 [A-P 2072]; Cole and Pratt, 1991 [A-P 2521]; Carey and Wigginton, 1990, 1991) (Figure 3).

Report AP-2072

A fault investigation by Rowley and McRae (1985) exposed evidence of Holocene displacement along traces of the Green Valley fault zone south of Highway 80 (faults shown in orange on Figure 3). Thirteen trenches totalling 731 meters and ranging in depth from 2.1 to 4.6 meters exposed Pliocene Tehama Formation and various alluvial, colluvial, and landslide deposits and soils. Trenches that were reported or inferred to have evidence of Holocene displacement along the Green Valley fault include TT-1, TT-2,TT-3, TT-5, TT-6, TT-8, TT-9, TT-10, and TT-13 (Figure 3).

Trenches TT-4 and TT-7 were excavated across a previously zoned branch fault mapped by Frizzell and Brown (1976) up to 91 meters east of the main fault zone (locality 13, Figure 3). No evidence of faulting or disruption of units was reported by Rowley and McRae. This eastern branch fault is generally poorly defined by a linear break in slope, based on air photo interpretation by this writer, and identified as an east-facing scarp by Frizzell and Brown. Additional geomorphic evidence of recent faulting associated with this break in slope was not observed by this writer. Rowley and McRae concluded that this eastern trace at locality 13 may not exist.

Traces of the Green Valley fault previously zoned in sections 24 and 13 were generally verified by Rowley and McRae (1985), although differences in detail exist (Figure 3). Mapping by Frizzell and Brown (1976), supplemented by Bryant (1982), was zoned for special studies in 1983. My air photo interpretation is generally similar to traces mapped by Rowley and McRae, although slight differences in detail exist. For example, in the southern part of sec 13, the 1983 SSZ map shows two traces in the linear trough (locality 14, Figure 3). Frizzell and Brown mapped a single trace through the center of the trough. Rowley and McRae mapped the fault in this trough farther to the east than either Frizzell and Brown or myself, based on trench exposures (their trenches TT-9 and TT-10). Trench TT-9 is not critical in the location of the westernmost trace of the Green Valley fault, but TT-10 is critical. Rowley and McRae reported a fault at the eastern end of TT-10 (station 2+90, N18°W 85°NE; stations measured from the west) that offsets Tehama Formation (?) claystone on the east against a sandy clay with some $CaCO_3$ development on the west. This fault closely coincides with a previously zoned trace. Farther west in trench TT-10 a possible older colluvial unit at station 1+80 (unit D of Rowley and McRae) thickens considerably within a 2.7-meter horizontal distance. The bottom of the trench is noticeably shallower at this location so the nature of this thickening was not revealed. Thus, although a fault has not been reported at this location, the presence of a fault has not been conclusively disproved. This western inferred fault is located about 15 meters east of the western zoned trace.

The fault bounding the eastern side of the linear ridge mapped by Frizzell and Brown generally is located too far to the east, based on mapping by Rowley and McRae and my air photo interpretation (locality 15, Figure 3). Frizzell and Brown based the location of this fault entirely on the presence of the elongate ridge and a poorly defined bench. My air photo interpretation indicates that the trace is located up to 46 meters west of the trace mapped by Frizzell and Brown, based on a closed depression, sidehill bench, and right-laterally deflected drainage (Figure 3).

Report AP-2521

A site investigation for a proposed freeway interchange, performed in the immediate vicinity of Highway 80 by Cole and Pratt (1991), found evidence for Holocene active traces of the Green Valley fault near locality 16 (Figure 3). Three trenches were excavated across previously zoned traces of the Green Valley fault. A fourth trench (T-2) did not encounter evidence of faulting nor did it cross a previously mapped fault. Trenches T-1, T-3, and T-5 were reported to have evidence of latest Pleistocene to Holocene faulting nearly coincident with the mapped traces, although the fault reported in T-5 lies about 30 meters east of the mapped trace (Figure 3).

T-1 was excavated where two nearly parallel traces previously were mapped (locality 16, Figure 3). A fault (N01°- 08°W, 59°- 72°E) reported at station 210 (stations measured from the east) offsets quartz-rich sand on the east against fine sandy clay on the west. A nodular $CaCO_3$ horizon (stage II) thought by Cole and Pratt to be approximately 20 to 28 ka is vertically displaced 0.55 meters by a subsidiary thrust fault (N78°W 28°S) located just west of the trace at station 210. The more vertically dipping fault offsets a weak stage I $CaCO_3$ horizon estimated by Cole and Pratt to be 4 to 9 ka. The principal fault reported in T-1 is located about halfway between two previously zoned traces (mapped traces are about 36.6 meters apart) (locality 16, Figure 3). The western of these two traces was not observed in T-1. Cole and Pratt postulated that the western trace may be located west of T-1. A trench was attempted in order to locate this fault, but had to be abandoned because of the excessive fill material encountered. Cole and Pratt assumed that the trace may offset Holocene channel deposits just west of those reported in the western end of T-1.

Evidence of Holocene displacement is not clear in trench T-3 (Cole and Pratt, 1991) (Figure 3). Fault planes were reported at stations 170 (N18°E 83°W) and 410 (N25°-36°E 61°-68°S) in this 137-meter long trench (stations measured from the west), but neither fault apparently offsets Holocene deposits. Although no fault planes were reported at station 30, alluvial deposits (clayey fine sands) are disrupted and folded, and a black clay unit with weak stage I $CaCO_3$ development abruptly thickens from about 0.3 meters west of the disturbed zone to about 1.2 meters within the disturbed zone. The concentration of $CaCO_3$ increases in this approximately 2.4-meter wide zone. Cole and Pratt speculated that the lack of fault planes in the younger clay-rich deposits may be explained by healing after a fault rupture event.

Faults exposed in the eastern end of trench T-5 offset Pliocene Sonoma Volcanics on the east against Eocene Markley Formation on the west. An approximately 6-meter-wide fault zone is delineated by faults that range from N27°W 82°NE to N14°W 82°NE. An approximately 9 ka stoneline is offset at station 30 (stations measured from the east) (Cole and Pratt, 1991). A test pit was excavated 9 meters south of T-5 in order to intercept the projected trace of the fault at station 30. Although this test pit was not logged due to time constraints, Cole and Pratt reported that all colluvial and soil units were offset and that drag folds in an approximately 5 ka deposit suggested a west side down vertical component of displacement along a N25°W 70°-80°SW fault.

Report AP-2185

The investigation by Lion and Ries (1988b) was located across previously zoned traces of the Green Valley fault in the northern part of the Cordelia quadrangle (locality 17, Figure 3). Two trenches were excavated across a concealed trace of the fault near the western end of the site (Figure 3). Unfaulted, nearly horizontal fluvial deposits of Holocene age were reported. Soils developed on this alluvium have a weak A-C horizon (Conejo Series) (Bates, 1977). Three additional trenches were excavated across the eastern part of the site in order to intercept the southern projection of a previously zoned inferred/queried trace (Figure 3). Evidence of faulting was not reported.

The Green Valley fault in the northern part of the Cordelia quadrangle is characterized by a postulated right-step or dilatational jog or bend, suggesting that the fault zone here is complex, probably consisting of short faults distributed over an area of unknown, but possibly significant, width. Further complicating the picture is that the northern Green Valley area has been farmed for a long period of time (predating the earliest air photo coverage). Also, a golf course located at the northern end of Green Valley also predates the earliest air photo coverage. Thus, a possibly distributive fault zone is poorly defined in this area and geomorphic features may have been destroyed by agricultural and developmental processes.

Carey and Wigginton, 1990

Carey and Wigginton (1990) excavated 12 trenches totaling 384 meters along or near the Green Valley fault in the southeastern part of the Cordelia quadrangle (locality 18, figure 3). Two branches of the fault were exposed. The eastern (main) trace was exposed in trenches T-3, T-4, and T-10A (Figure 3). A secondary, western trace was exposed in T-12 (Figure 3).

The main trace is well-defined by a sharp linear tonal contrast and a left-laterally deflected drainage. This eastern trace aligns with the well-defined trace trenched by Dames and Moore (1972) to the north (see Bryant, 1982). The fault (N29°W 89°S) exposed in trenches T-3, T-4, and T-10A extends to within 1 meter of the ground surface as a discrete shear and, locally, offsets a black (5Y 2.5/2) sand clay unit interpreted by this writer as a possible A horizon. This fault zone exposed in T-4 consists of an approximately 7 meter wide zone of shearing. The base of the inferred A horizon is offset (apparent vertical separation) a total of 0.5 meters across three shears.

The secondary western trace, partly zoned for special studies in 1983, was extended farther north by Carey and Wigginton, based on moderately defined linear tonal contrasts (locality 18, Figure 3). The fault was reported near the western end of trench T-12 (Figure 3). A steeply east-dipping fault juxtaposes unit 2 (a probable Bt horizon) against a very dark grey (5YR 3/1) silty clay. The fault extends to within 1 meter of the ground surface, but apparently doesn't offset the A soil horizon. Carey and Wigginton (1990) and Carey (1991) concluded that this western trace was Holocene active and building setbacks were recommended.

Carey and Wigginton, 1991

An investigation by Carey and Wigginton (1991) exposed evidence of Holocene faulting along two strands of the Green Valley fault just south of I-80 (locality 19, Figure 3). Carey and Wigginton concluded that the eastern branch, located along the eastern side of a linear ridge developed in Pliocene Tehama Formation, was the principal active trace and the trace located on the west side of the linear ridge was a less active secondary trace.

Evidence of Holocene activity along the eastern trace was reported in trench E-1 (locality 19, Figure 3). A fault (N15°W 60°W) is delineated by an approximately 1 meter wide shear zone. Different alluvial units are juxtaposed across the fault, indicating strike-slip displacement. The base of an offset A horizon was determined to be 1955 $\pm$ 145 radiocarbon years old.

Evidence of probable Holocene displacement along the western trace was reported in trenches E-2, E-7, and E-8 (locality 19, Figure 3). Faulting within these trenches is not as well-defined as the eastern trace. Faulting is expressed principally as thickening of soil horizons developed on alluvium/colluvium, and is locally associated with vertical parting and truncation of a thick manganese horizon. Significantly, trench E-3 did not expose evidence of faulting in latest Pleistocene and Holocene alluvium (Figure 3). This trace was zoned in 1983, but interpretation of aerial photos by this writer indicates that the fault trace is located to the east, based on the presence of a vague linear tonal contrast. This location tends to be supported by Carey and Wigginton (1991). Building setbacks were recommended for both the eastern and western traces.

AERIAL PHOTOGRAPHIC INTERPRETATION AND FIELD INSPECTION

There are slight differences in fault location at the southern end of the Cordelia quadrangle mapped by Frizzell and Brown (1976) and Bryant (this report) (Figure 3). The fault zone south of locality 20 is generally located in massive landslide deposits of various ages, so the exact location of the fault often is problematical. To the north, a minor branch fault mapped by Frizzell and Brown located just west of the main trace is defined by a linear bench (possible Qls) and a linear tonal contrast (locality 21, Figure 3). The main trace may lie closer to this branch fault in the northwest corner of section 31. The main trace mapped by Frizzell and Brown appears to have been based on the presence of a linear drainage and a saddle. However, I mapped the fault farther west higher on the saddle, based on geomorphic features indicative of faulting immediately to the south, including a right-laterally deflected drainage, truncation of a unit expressed by boulder outcrops Sonoma Volcanics (?), and a sidehill bench and associated tonal lineament (locality 22, Figure 3).

ASEISMIC CREEP

Aseismic fault creep has been reported along the Green Valley fault by Dames and Moore (1972), Dooley (1973b), Frizzell and Brown (1976), and Galehouse (1991). Frizzell and Brown reported that a right-lateral offset of 0.25 meters along a stone fence built sometime before 1862 (locality 23) and a 0.28 meter right-lateral offset of a power transmission tower alignment built in 1922 (locality 24) yield creep rates (as of 1974) of 2.2 mm/yr and 5.4 mm/yr, respectively (Figure 3). A barbed wire fence of unknown age is offset about 0.3 meters at locality 27 (Figure 3).

Galehouse (1991) reported an aseismic creep rate of 5.7 mm/yr for the Green Valley fault. This rate has been determined from repeated measurements of a triangulation net over the last 10 years (locality 25, Figure 3). It is not clear how the creep rate reported by Galehouse may relate to long term strain accumulation across the Green Valley fault. If the Green Valley fault had been creeping at a constant rate of 5.7 mm/yr, one would expect the stone fence reported by Frizzell and Brown to be right-laterally offset at least 0.7 meters. Although Galehouse reported that the Green Valley fault has a historic creep rate of 5.7 mm/yr, there is no evidence of offset cultural features along the Green Valley fault in the Vine Hill quadrangle, based on field observations by this writer (locality 26, Figure 2b).

SEISMICITY

There is no well-defined zone of microseismicity along the Green Valley fault in the Benicia/Cordelia study area for the period 1932-1985 (CIT, 1985). There are a few scattered earthquakes in the M 1-2 range near the northern end of the Cordelia quadrangle. A cluster of epicenters (M 1-3) is located in the Sulpher Springs Mountain area about 5 km west of the Green Valley fault, but probably are quarry blasts.

CONCLUSIONS

FAIRFIELD SOUTH AND VINE HILL QUADRANGLES

The Green Valley fault in the Fairfield South and Vine Hill quadrangles generally is well-defined and is delineated by geomorphic features indicative of Holocene right-lateral strike-slip faulting, including right-laterally deflected drainages, sidehill benches and troughs through latest Pleistocene and Holocene landslide deposits, closed depressions, beheaded drainages, and linear tonal contrasts (Figures 2a and 2b). These features generally occur along the principal active trace, or Western trace, mapped by Frizzell and Brown (1976), Sims and others (1973) (locally), and Bryant (this report). Faults mapped by Frizzell and Brown generally were verified by this writer as shown in Figures 2a and 2b. I could not verify the presence of ephemeral geomorphic features indicating strike-slip faulting along the west side of the linear ridge north of locality 11 mapped by Frizzell and Brown and Sims and others (Figures 2a and 2b). The fault trace was not recommended for zoning by Bryant (1982) and I see no compelling reason to reverse this zoning decision.

The branch fault mapped by Frizzell and Brown and Dooley near localities 3 and 5 (Figure 2a) was partly verified based on air photo interpretation, though considerable differences in detail exist (Figures 2a and 2b). The short trace mapped by Frizzell and Brown just west of the principal trace was not verified (locality 6, Figure 2a).

Faults mapped by Sims and others were not verified in detail except for the southernmost Western trace, which I consider to be the principal active trace (Figure 2a). Faults mapped by Dooley (1973) generally were not verified except for a short strand of the fault in the vicinity of locality 5 (Figure 2a). However, the fault mapped by Dooley trends more to the east near the linear ridge in Sonoma Volcanics (locality 9, Figures 2a and 2b). This part of the fault, also mapped by Frizzell and Brown, was not verified.

The Eastern trace of the Green Valley north of locality 5 was mapped by Frizzell and Brown and, locally, by Sims and others. I also mapped this fault, mostly as a southeastern projection of the fault delineated by a linear sidehill bench at locality 10 (Figure 2b). South of locality 12 the fault lacks geomorphic evidence of Holocene faulting (Figure 2b). The geomorphic features delineating this strand (saddles and benches) are not necessarily indicative of recently active faulting.

CORDELIA QUADRANGLE

Traces of the Green Valley fault zoned for special studies in the Cordelia quadrangle in 1983 were generally verified in investigations by Rowley and McRae (1985), Cole and Pratt (1991), and Carey and Wigginton (1990, 1991) (Figure 3). The investigation by Cole and Pratt indicated Holocene activity along previously zoned traces of the Green Valley fault. The only exception was the western trace near trench T-1 (locality 16, Figure 3). This trace, based on mapping by Frizzell and Brown (1976) and a trench exposure by Burkland and Associates (1973), may be located just west of Cole and Pratt's trench T-1.

Investigations by Rowley and McRae (1985) and Carey and Wigginton (1990, 1991) generally confirmed the location of Holocene active strands of the Green Valley fault as previously zoned in 1983, although minor differences in detail exist (Figure 3). An eastern branch fault mapped by Frizzell and Brown (1976) and zoned for special studies in 1983 was not observed in trenches TT-4 and TT-7 (locality 13, Figure 3). Rowley and McRae concluded that this eastern branch may not exist. Geomorphic evidence for the existence of this eastern branch is weak, consisting of a linear break-in-slope with no associated geomorphic features. The northeast-facing scarp reported by Frizzell and Brown was not verified by this writer, based on air photo interpretation (Figure 3). It is concluded that the removal of this trace is warranted.

The fault trace bounding the eastern side of the linear ridge mapped by Frizzell and Brown is located too far to the east, based on mapping by Rowley and McRae and air photo interpretation by this writer (locality 15, Figure 3). This trace should be revised to incorporate the mapping of Rowley and McRae and this writer.

The investigation by Lion and Ries (1988b) did not find evidence of faulting in Holocene fluvial deposits (locality 17, Figure 3). This area is characterized by a postulated right-step or dilatational jog or bend in the Green Valley fault, which suggests that the fault zone in this location is complex, possibly consisting of short faults distributed over an area of unknown, but possibly significant, width. Although the investigation by Lion and Ries trenched a previously zoned concealed trace of the Green Valley fault, removal of the zone in this area is not warranted because of the probable distributive nature of the fault, the relatively young Holocene fluvial deposits in Green Valley, and the probable destruction of ephemeral geomorphic evidence of faulting due to years of agricultural use.

RECOMMENDATIONS

Recommendations for zoning faults for special studies are based on the criteria of "sufficiently active" and "well-defined" (Hart, 1990).

FAIRFIELD SOUTH AND VINE HILL QUADRANGLES

Zone for special studies well-defined traces of the Green Valley fault mapped by Frizzell and Brown (1976) and Bryant (this report) as depicted in green on Figures 2a and 2b. Principal references cited should be Frizzell and Brown (1976) and Bryant (this report).

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Zone for special studies well-defined traces of the Green Valley fault highlighted in green on Figure 3. Slight modifications to the existing traces zoned in 1983 are as follows: 1) Delete the eastern branch fault mapped by Frizzell and Brown (locality 13, Figure 3). 2). Move the easterly trace of Frizzell and Brown at locality 3 to conform to mapping by Rowley and McRae (1985) and this writer as shown in Figure 3. 3). Modify the western trace near locality 19 (Figure 3) to conform to the mapping of Carey and Wigginton (1991) and this writer (Figure 3). Additional minor changes are indicated in Figure 3. Principal references cited should be Dames and Moore (1972), Frizzell and Brown (1976), Rowley and McRae (1985), Bryant (1982), and Bryant (this report).

Reviewed; recommendations approved. Earl W. Hart Program Mgr. 3/18/92

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REFERENCES

Bates, L.A., 1977, Soil survey of Solano County, California: U.S. Department of Agriculture, Soil Conservation Service, 112 p. 53 plates.

Brown, R.D., Jr., 1970, Faults that are historically active or that show evidence of geologically young surface displacement, San Francisco Bay region, a progress report; October 1970: U.S. Geological Survey Miscellaneous Field Studies Map MF-331, scale 1:250,000.

Bryant, W.A., 1982, Green Valley fault: California Division of Mines and Geology Fault Evaluation Report FER-126, 18 p.

Bryant, W.A., 1991, The Green Valley fault in Figures, S. (editor) Field Trip Guide to the Geology of Western Solano County: Northern California Geological Society and Association of Engineering Geologists, Field Trip of October 12, 1991, p. 1-11.

Burkland and Associates, 1973, Geologic investigation, Villages and Cordelia - Phase I, Solano County, California: Unpublished consulting report (C-53).

California Division of Mines and Geology, 1974, Official Special Studies Zones Map of the Fairfield South quadrangle, scale 1:24,000.

California Division of Mines and Geology, 1977, Official Special Studies Zones Map of the Port Chicago quadrangle, scale 1:24,000.

California Division of Mines and Geology, 1983, Official Special Studies Zones Map of the Cordelia quadrangle, scale 1:24,000.

California Institute of Technology, 1985, Magnetic tape catalog, California earthquakes for the period 1932 to 1985: Seismological Laboratory, California Institute of Technology (unpublished).

Carey, D. 1991, The Green Valley fault zone between Marsh View Road, and Highway 80, Cordelia, California in Figures, S. (editor) Field Trip Guide to the Geology of Western Solano County: Northern California Geological Society and Association of Engineering Geologists, Field Trip of October 12, 1991, p. 17-23.

Carey, D. and Wigginton, W.B., 1990, Alquist-Priolo seismic hazard fault study, Garibaldi Property, Fairfield, California: Concord, California, Engeo Inc., unpublished consulting report for Seecon Financial and Construction Company, Engeo project no. N90-3119-E1 (g), December 28, 1990, 31 p., 3 plates.

Carey, D. and Wigginton, W.B., 1991, Fieldcrest, Cordelia, California, Alquist-Priolo Seismic Hazard fault study: Concord, California, Engeo Inc., unpublished consulting report for Seecon Construction Company, Engeo project no. N1-3215-E3, 27 p. 3 plates, 3 appendices.

Cartwright Aerial Survey, 1965, Aerial photos SOL 47-239 to 247 and 48-114 to 117, black and white, vertical, scale 1:12,000.

Cole, K.A. and Pratt, J., 1991, Fault investigation of the Green Valley and Cordelia faults, Solano County: San Francisco, California, California Department of Transportation, District 4, unpublished consulting report, February 19, 1991, 7 p., 7 plates (AP-2521).

Dames and Moore, 1972, Engineering-geology and seismic evaluation, proposed multi-use development, Cordelia, California: Unpublished consulting report (C-44).

Dooley, R.L., 1972, Geology along the Green Valley fault, Solano County, California: California Division of Mines and Geology open-file report, 15p.

Dooley, R.L., 1973a, Written Communication to California Division of Mines and Geology.

Dooley, R.L., 1973b, Geology and land use considerations in the vicinity of the Green Valley fault: University of California, Davis, unpublished M.S. thesis, 47 p.

Frizzell, V.A., Sims, J.D., Nilsen, T.H., and Bartow, J.A., 1974, Preliminary photointerpretation map of landslide and other surficial deposits of the Mare Island and Carquinez Strait 15-minute quadrangles, Contra Costa, Marin, Napa, Solano, and Sonoma Counties, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-595 (also Basic Data Contribution 67).

Frizzell, V.A., Jr. and Brown, R.D., Jr., 1976, Map showing recently active breaks along the Green Valley fault, Napa and Solano Counties, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-743, scale 1:24,000.

Galehouse, J. 1991, Present-day creep on the Green Valley fault in Figures, S. (editor) Field Trip Guide to the Geology of Western Solano County: Northern California Geological Society and Association of Engineering Geologists, Field Trip of October 12, 1991, p. 12-16.

Geomechanics, Inc., 1978, Geologic investigation for villages of Cordelia-Village I: Unpublished consulting report (AP-1008).

Hart, E.W., 1976, Concord fault: California Division of Mines and Geology Fault Evaluation Report FER-2, 3p.

Hart, E.W., 1990, Fault-rupture hazard zones in California: California Division of Mines and Geology Special Publication 42 (revised), 26 p.

Helley, E.J. and Herd, D.G., 1977, Map showing faults with Quaternary displacement, northeastern San Francisco Bay Region, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-881, scale 1:125,000.

Lion, T.E. and Ries, T.C., 1988a, Fault location study, Drake Industrial Park, Lake Herman Road and I-680, Benicia, California: Cordelia, California, Kleinfelder, unpublished consulting report for Southern Solano Industrial Development Group, Kleinfelder project no. 40-1940-01, 13 p., 14 plates (AP-2184).

Lion, T.E. and Ries, T.C., 1988b, Fault location study, Locke subdivision, Green Valley Road at De Leu Road, Solano County, California: Cordelia, California, Kleinfelder, unpublished consulting report for Louis Locke, June 27, 1988, Kleinfelder project no. 1992-01, 11 p., 10 plates (AP-2185).

Manson, M.W., 1988, Landslide hazards in the Cordelia-Vallejo area, Solano and Napa Counties, California: Landslide Hazard Identification Map No. 13: Division of Mines and Geology Open-File Report 88-22, 4 sheets, scale 1:24,000.

Pampeyan, E.H., 1979, Preliminary map showing recency of faulting in north-central California: U.S. Geological Survey Miscellaneous Field Studies Map MF-1070, scale 1:250,000.

Rowley, R.P, and McRae, C.M., 1985, Engineering geology evaluation report, Cordelia Villages - Phase II, Cordelia, California: Cordelia, California, Kleinfelder and Associates, unpublished consulting report for Albert D. Seeno Construction Company, Kleinfelder and Associates project no. C-1480-1, April 5, 1985, 25 p. 9 plates (AP-2072).

Sims, J.D., Fox, K.F., Jr., Bartow, J.A., and Helley, E.J., 1973, Preliminary geologic map of Solano County and parts of Napa, Contra Costa, Marin, and Yolo Counties, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-484, scale 1:62,500.

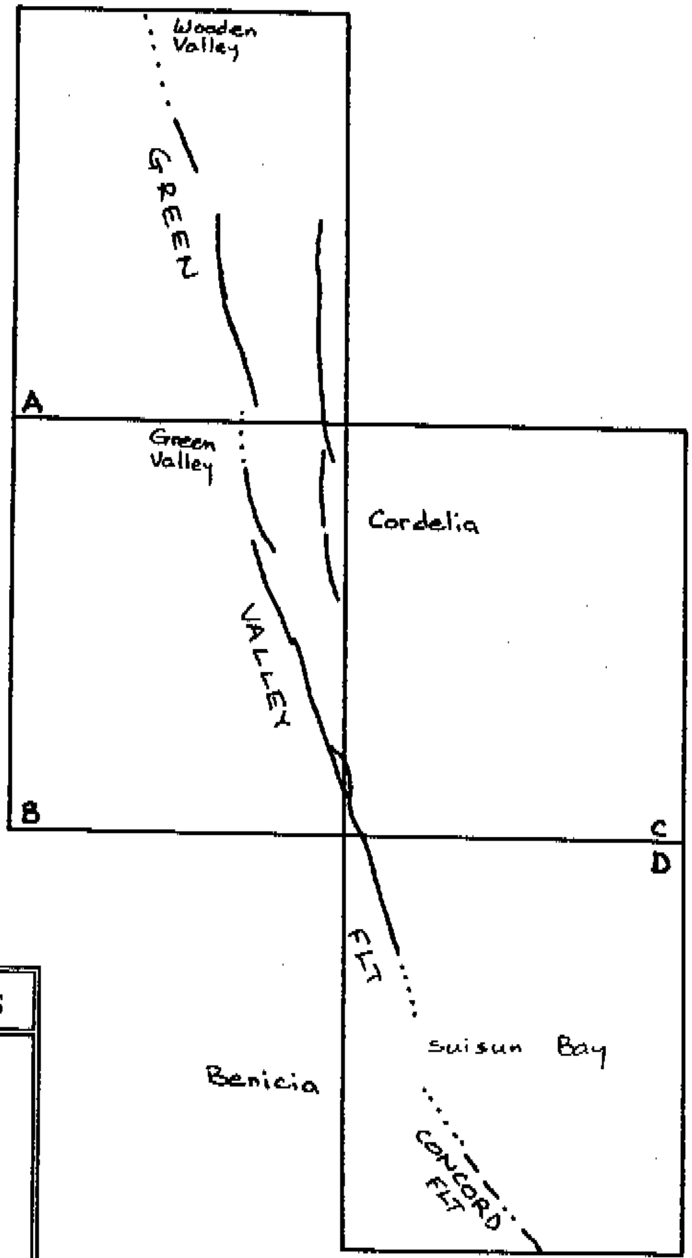
U.S. Department of Agriculture, 1952, Aerial photographs ABO-3k-72 to 75, 123 to 133, black and white, vertical, scale approximately 1:20,000.

U.S. Geological Survey, 1973, Aerial photographs 3-57 to 63, 86 to 89, low sun angle, color, vertical, scale approximately 1:24,000.

U.S. Geological Survey, 1974, Aerial photographs 10- 1 to 8, 17 to 18, low sun angle, color, vertical, scale approximately 1:36,000.

Wagner, D.L. and Bortugno, E.J., 1982, Geologic map of the Santa Rosa quadrangle, California: Division of Mines and Geology Regional Geologic Map No. 2A, scale 1:250,000.

Weaver, C.E., 1949, Geology and mineral deposits of an area north of San Francisco Bay, California: California Division of Mines Bulletin 149, 135 p.



INDEX TO QUADRANGLES

A. Mt. George
B. Cordelia
C. Fairfield South
D. Port Chicago (now Vine Hill)

Figure 1 (to FER-232). Location of the Green Valley fault in the Cordelia/Benicia study area. Fault traces are generalized from Wagner and Bortugno (1982), scale 1:250,000.